PROJECT REPORT

Smart Moves: Making Sense of the Math in Environmental Data

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Abstract

Environmental organizers and their constituents, local community group members concerned about environmental health, operate in a context with rich and varied opportunities for learning about and applying mathematics to communicating environmental data. Prior to Statistics for Action, project partners—organizers at environmental non-profits—spent little time with group members analyzing data. Organizations did not have a method or protocol for considering the most effective way to frame findings for neighbors and decision makers. During the Statistics for Action Project, STEM educators and environmental organizers collaborated to use the context of environmental organizing as a platform for science and math learning. This article describes Smart Moves and Memorable Messages, two approaches that advanced goals for both math learning and organizing.

Rationale and Significance

Community members who live close to polluting facilities or toxic sites are often among the first to recognize the threats to human health. The historic pattern of placing polluting industries in or near low-income neighborhoods means that residents in these communities carry an unequal burden of negative health effects from environmental contamination (Faber and Krieg 2002). Bolstering the effectiveness of community groups organizing to clean up, curtail, or close down polluting operations has the potential to make a positive difference in human and environmental health. Local community groups that are well organized often prevail, gaining environmental protections and limiting negative health effects (Bullard 1993; Scammell and Howard 2013; see also annual reports for organizations such as Center for Health and Environmental Justice[1] and Toxics Action Center[2]).

1 http:// http://chej.org/wp-content/uploads/CHEJ-Annual-Report-2015.pdf (accessed June 22, 2016)

2 http://www.toxicsaction.org/about/mission-and-history (accessed June 22, 2016)

The *Statistics for Action* (SfA) project brought adult educators together with environmental organizers to create and test a set of activities and guides. The goal was to promote math and science learning for community group members involved in environmental campaigns in a way that would strengthen data-driven advocacy efforts. Organizing provokes concern and motivates concerned residents to action. Attention to science and math learning may happen as part of a larger organizing effort. Generally it is a means to an end. In spite of differing priorities, SfA project partners saw potential benefits to promoting math and science learning in the context of community organizing.

After a few false starts, SfA's team of educators and organizers agreed on messaging with data as an area of focus. Typically when organizers and community members query experts and regulators, they are treated to a fire hose of information. Daunting amounts of data call for strategies for both making sense of data and communicating key points once they are identified. Thus, the project's educators drafted a set of "Smart Moves" for math learning. Organizers embraced the norms for guiding mathematically rich conversations. The Smart Moves and SfA communication activities described below can be a useful starting point for other projects blending environmental advocacy and education.

Background and Questions

While observing community group meetings, science and math educators found that most groups struggled to make sense of technical documents such as environmental quality reports and standards for contaminants. Among these groups, three strategies for managing environmental data in technical documents were evident:

- Avoid the data and analysis altogether; focus on other tasks
- Find an expert to assist
- Delegate data management to a group member with a science, math, or engineering background.

Given that international assessments paint a dismal picture of U.S. adults' basic numeracy skills (Goodman et al. 2013), such strategies make sense. By opting out, delegating, or contracting out a careful look at the technical documents, however, groups often lose out on the opportunity for all of their members to use data in creative ways to advance their cause. What if a fourth strategy were viable? The project's formative research examined to what extent environmental organizers who are trusted by local community group members could be conduits for science and math learning. Project leaders, partners, and evaluators were convinced that if provided with a robust set of resources, organizers could effectively facilitate math learning. Project partners envisioned that with guidance from an organizer, all members of a community group would engage with local environmental test results, and in the process gain increased confidence in communicating the processes and findings to neighbors and decision makers. Educators on the project team also hypothesized that group norms or ground rules would be critical to establishing trust and engagement for doing math in community group settings.

Context and Players

Over 50 organizers used draft versions of SfA's activities and guides to promote understanding of environmental testing (final versions are available for free at sfa.terc.edu). Organizers worked in cities, towns, suburbs, and rural communities in North Carolina, California's Central Valley, New England states, and Chicago, Illinois. Prior to applying for funding, math educators interviewed staff at nine environmental organizations leading a variety of campaigns seeking improved environmental quality and advocating for human health. Four of the interviewees recognized the potential benefits for increased understanding of environmental data among their staff and community members. The four organizations—Blue Ridge Environmental Defense League, Pesticide Watch Education Fund, Little Village Environmental Justice Organization, and Toxics Action Center—were named in the proposal for funding Statistics for Action and were active partners during the project. These organizational leaders then designated staff to participate in Statistics for Action professional development. Campaign issues ranged from methyl iodide use in California's strawberry fields to containing the operations of a junkyard in Vermont. A number of issues were on residents' minds:

fumes from an asphalt plant, toxins from a medical waste incinerator and a galvanizing plant, water contamination from a recently closed textile or pesticide manufacturer. Interested readers can find stories and accompanying educational materials in the *Change Agent* issue on Staying Safe in a Toxic World (http://sfa.terc.edu/materials/changeagent.html). Toxics Action Center played a key role early in the project, giving feedback on draft versions of materials. It hired staff with experience in grass-roots organizing, but initially just one had a degree in environmental science. Over time more organizers and organizations were recruited to use SfA materials through project advisors' networks and conferences. The majority were college-educated young women, though organizers ranged in age from 23-60+. They played diverse roles on the project, recruiting community groups for pilot testing, supplying data sets, fleshing out stories, and reviewing materials. They offered feedback after using activities and participated in quarterly conference calls to share best practices. A core group of eleven participated in evaluation activities including surveys before and after being introduced to SfA and annual interviews.

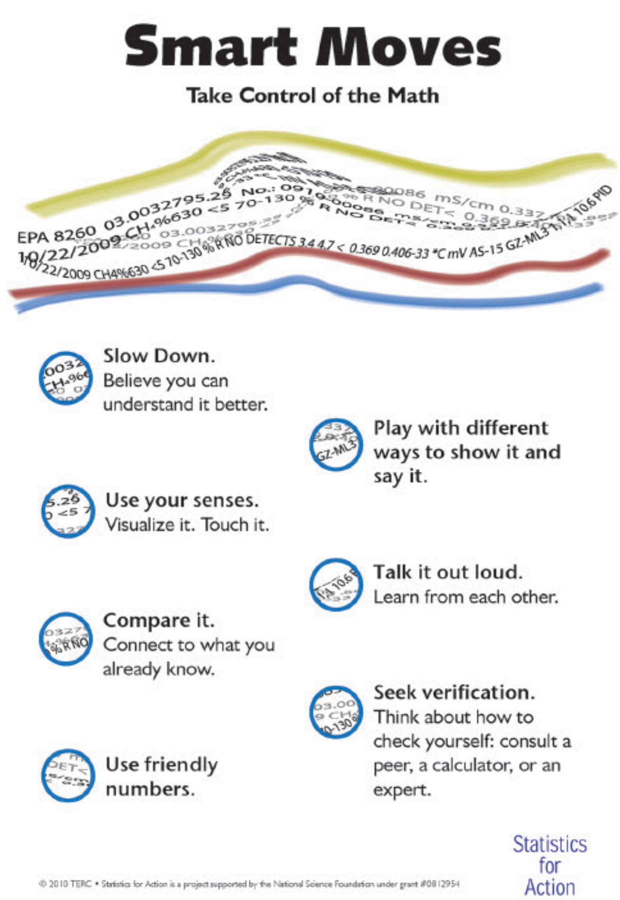
Conditions under which organizers work are challenging. Unlike settings such as museums and nature centers which offer recreation, family-friendly learning opportunities, or entertainment, an environmental campaign asks adults to attend lengthy meetings and to volunteer for unpaid work. Meetings about environmental campaigns can be emotional. Residents are often angry about past wrongs and stressed about future outcomes and current impacts on their health. Meeting agendas may shift at the last minute due to newly released data or a change in hearing dates. Key group members may become ill or move away. In keeping with the characteristics of science and math learning in informal venues, challenges and opportunities arise from the compelling, learner-driven but unpredictable nature of learning opportunities in environmental organizing (Allen and Gutwill 2011).

New Practices for Facilitating STEM Learning: Smart Moves and Memorable Messages

Using the Smart Moves

SfA educators introduced a list of Smart Moves that set group norms when math-reticent or math-phobic participants would be asked to do math during a group meeting that could include mathematically confident peers. An educator with many years of experience drafted the first set of Smart Moves in the project's first year. The Smart Moves were printed on 11"x17" paper and presented as a poster that could hang during a community meeting or workshop. At professional development sessions for environmental organizers in the first two years of the four-year project, SfA educators modeled using the Smart Moves both as ground rules, reviewed before any activities or taxing mathematics, and as facilitation strategies, guiding small group work. On an annual basis SfA's materials were revised and updated. SfA educators reviewed and tweaked the wording of the Smart Moves at these

FIGURE 1.



junctures in order to be in synch with organizers' sensibilities. Smart Moves were popular with several environmental organizers who posted them, read them aloud, or modeled them in their work with community members. During community group meetings and conference sessions, organizers regularly preceded activities on environmental data with a review of the Smart Moves. This practice was not mandated, but rather left to organizers, who generally posted and mentioned the Smart Moves at formal workshops. In meetings in living rooms with fewer than 10 people, explicit references to Smart Moves were less common.

Slow down; Talk it out.

These moves invite exploring the implications of numbers. Even if several members of a group can quickly convert measurements in micrograms to parts per billion, the group should take time, slowing down to make sure everyone follows. In so doing, participants have a chance to absorb the full impact of the quantities. Smart Moves can also be shared in advance with experts, academics, and regulators scheduled to present to community members. When experts, academics, and regulators present to community members, "slow down" reminds them to pause as they rattle off numbers, letting the audience absorb a statistic before stating the next one. "Talk it out" reminds everyone that in this setting people can talk and laugh, work alone or with others, and clarify their thinking by explaining aloud to a peer.

Connect ideas to what people already know; Appeal to the senses; Show numerical relationships in more than one way.

Relating to something familiar is an effective strategy for taking in new information (Willingham 2010) and makes ideas stick. Props as well as tactile experiences make a lasting impression. A Sweet'N Low™ packet conveys the weight of one gram more quickly than words can. A visual aid or physical object grounds understanding of amounts relative to one kilogram (especially handy in the world of milligrams per kilogram). Presenting numerical relationships in more than one way (using raw numbers, percentages, ratios in simplest terms, and approximate fractions as well as analogies and props) invites people who are not so proficient with mental math to visualize the relationships.

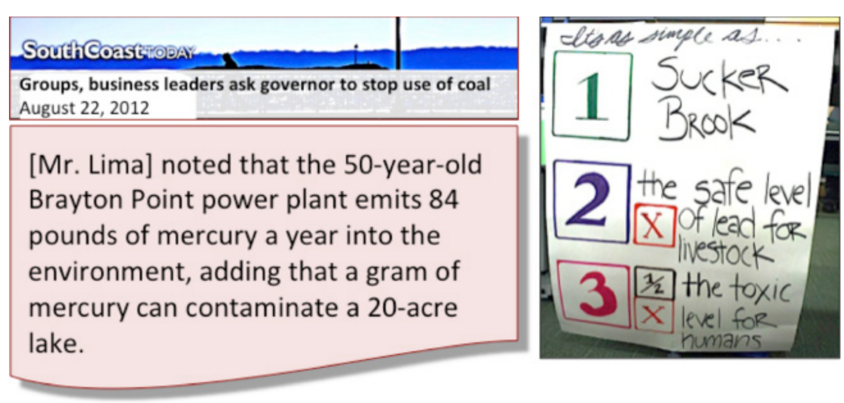
Verify.

Choosing the right level of precision is something community group members talk about as they craft messages. Groups have to be strategic. They base their arguments on numbers from sources such as the Centers for Disease Control, annual reports or press releases from facility owners or proposers, or from an environmental impact statement. The stakes are high; credibility is on the line. If a community group or organizers disseminate information that is subsequently shown to be false, they are discredited and dismissed. The Smart Moves thus include advice to verify claims and findings.

Besides dispelling excuses about not being good at math, the Smart Moves made explicit the expectations for participating in an SfA activity. Smart Moves introduced a way of doing math distinct from the school experience common to most adults, in which silence was expected, dialogue discouraged, and reasoning out a problem with another student was interpreted as cheating. The Smart Moves can be used for problem solving in any domain. Below we explain how they were relevant to environmental organizing. Some organizers quickly adopted the Smart Moves, seeing them as a bridge or transition to activities. One organizer said:

> "Having an environmental studies background doesn't pre-

FIGURE 2.



pare you to be a teacher. As a quasi-teacher, it was very helpful to have the Smart Moves. They were a reminder to the community members of how to tackle the math and science, and taught everyone, including me, very quickly what to do and what not to do."

FIGURE 3. Sample Memorarable Messages — How toxic is dioxin?

The legal limit for dioxin in drinking water is 0.0003 micrograms/L. That's the same as 1 gram of dioxin added to 8.8 billion gallons of water.	1 gram of dioxin is enough to poison the amount of water the average American would use in 15,000 years.
1 gram of dioxin is enough to poison the water that 15,000 Americans use in one year.	1 gram of dioxin would make 8.8 billion gallons of milk unsafe to drink.
1 gram of dioxin would poison 13,333 Olympic sized swimming pools' worth of water.	1 gram of dioxin would make the amount of water used by all of the people of Concord, MA unsafe to drink for a year.
One half-gram of dioxin would poison all the water in Walden Pond.	1 gram of dioxin is enough to make 33 billion liters of soda unsafe to drink.

Messaging Activities

Community groups' main focus is to convince others of the need for action. Finding effective ways to share data on environmental conditions is clearly central to the work. The **Memorable Messages** activity sparks discussions on effective communication. It also encourages slowing down while modeling the use of different numerical representations. For this activity, everyone in the group reads one environmental fact and alternative versions restating that fact. The facilitator asks everyone (in pairs) to speak to the statements: *Which one makes the most powerful impression? Which one is least impressive to you?*

Once organizers facilitated Memorable Messages, they engaged group members in crafting and discussing alternate messages for the local campaign. When confronted with unwieldy quantities or units, one strategy is to scale numbers up and down until one finds a quantity in a unit that is easier to grasp or that uses some familiar element so that the unwieldy quantity makes a strong impression. The next step is to situate these quantities in a context/in a statement that makes it easier for the audience to imagine the impact. Participants stated and restated amounts and relationships, reflecting on the impression that each statement made.

For example, participants restated a fact about emissions from a proposed biomass incinerator. The permit stated that the facility could emit up to 246.8 tons per year of carbon monoxide, nitrogen oxides, and sulfur dioxide. With the population of the host county at hand, the group adjusted time and quantities, generating and critiquing versions of the original fact, such as

- About a pound of carbon monoxide per person in the air all the time.
- Figure out how much CO is in one cigarette. Say it's like smoking X cigarettes.
- Inhaling 0.13 pounds of each of these pollutants per day per person.
- The amount per day works out to one can of toxic soup.
- Imagine the fifteen pounds of carbon monoxide and other chemicals sitting on your head for 365 days a year. That'd have an effect on you!

Participants debated the pros and cons of each statement. One person said 0.13 pounds didn't sound impressive. Fifteen pounds of carbon monoxide was impressive-sounding, but a "can of toxic soup" was easier to visualize. Discussions with attention to quantity, analogies, and scale became a routine part of environmental organizers' work with community groups, often followed by conversations to further refine a statement and verify the claim with an expert.

Discussion

Notes from meetings and calls documented organizers' enthusiasm and efforts as well as their resistance to facilitating certain activities. Among activities that were ignored or rejected were those that needed props, extensive set-up, had accompanying worksheets that organizers deemed elementary in look or content, and those that involved practice without a clear connection to moving the campaign forward. Project partners initiated a set of practices focused on messaging and communication, which were perceived as useful by organizers and participants. When asked for feedback on a short survey, participants in workshops and trainings were positive and confirmed the potential impact of the SfA resources. Of the 187 surveys collected in the project's final year, ninety percent of participants agreed that doing an SfA activity gave them more confidence to speak about the topic; sixty percent (n=183) felt confident in understanding the issue after the activity compared with twenty-eight percent before (Connors et al. 2013).

Organizers persuaded STEM educators that activity names and goals had to have a mission-based, campaign-focused objective. SfA's educators worked to convince organizers that examining and incorporating data could strengthen the points that organizers were hoping to make through stories. In fact sheets, testimony, press releases, *and* in-person conversations, community members needed to weave numbers and stories into their communications. A community organizer commented on her transformation: "I tended to gloss over these issues before because they overwhelmed community members. Now I have a set of tools to address sorting out numbers, messaging, figuring out how to make sense of data and communicate risk."

Collaboration resulted in more conscious, intentional use of data during meetings, leading community members to listen for sound bites they would use in communicating with others on environmental topics. The project's external evaluators found that adding facilitating science and math learning to their repertoire of assistance to community groups was doable but not trivial for organizers. See Arbor Consulting Partners *Evaluation of Statistics for Action Final Report* (Connors et al. 2013) for more detail. There is much work to be done to understand who gets up to speed and how. We concur with Lemke et al. (2015), who call for assessment strategies that could capture know-how and know-who as well as know-that. Assessment should examine evidence that knowledge is being used and that this use persists, grows, and cumulates over relatively long periods.

Conclusion

Working alongside environmental organizations can have a huge payoff for STEM educators interested in reaching underserved audiences, including rural and inner city residents with limited formal education. Though community members may expect that educators will do all the math and understanding *for* them, the opportunities for collaborative teaching and learning are authentic, as all group members have relevant experience or knowledge to contribute, even though most do not have technical expertise or formal education in environmental science.

SfA was founded on the premise that *all* group members can contribute to the scientific and mathematical aspects of the work involved in environmental organizing. From its inception, the project has sought ways to expand the number of individuals investigating the math and science from one or two to the wider group. Smart Moves were a tangible signal that everyone could step onto the playing field. Our experience is that certain practices and approaches are a useful starting point for collaborations centered on environmental campaigns. SfA activities and resources are free and online (sfa.terc.edu), available to support environmental organizers who want to facilitate math and science understanding. The materials are relevant for educators and others interested in using environmental data sets in the classroom. Each activity includes a facilitators' sheet with information like the skills addressed, suggestions for launching and debriefing the activity, and hints for preparation, as well as the most salient Smart Moves.

Organizers' role in this transformative work is critical. We leave the last word to an organizer who benefitted from approaches generated by the SfA collaboration of organizers and STEM educators.

> *My general orientation before this project was that those sorts of fact and figures—we don't really want to tell those in our story, people don't understand them, we don't have the tools to understand them....*
>
> *I've had a small but fundamental shift in my orientation in thinking about and telling the stories of the campaign that we're working on.... I think that in general, figuring out how to describe problems and solutions when it comes to pollution and environmental health using numbers and coming up with powerful messages and powerful details to help flesh out the story is helpful for campaigns (Connors et al. 2013).*

About the Authors

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